The Alaska SAR Facility: Overview and Key Geophysical Applications

Verne Kaupp
Alaska SAR Facility, Geophysical Institute
University of Alaska, Fairbanks
Fairbanks AK 99775-7320
907-474-7263, 907-474-6441 (Fax), vkaupp@images.alaska.edu

Benjamin Holt
Jet Propulsion Laboratory, California Institute of Technology
Mail Stop 300-323, 4800 Oak Grove Drive, Pasadena, CA 91109
818-354-5473, 818-393-6720 (Fax), ben@pacific.jpl.nasa.gov

Abstract. The Alaska SAR Facility (ASF) is the NASA Distributed Active Archive Center (DAAC) that provides SAR (synthetic aperture radar) data and data products to polar and earth systems science communities and to operational agencies. ASF currently supports the ERS-1 and ERS-2 flown by the European Space Agency (ESA), JERS-1 flown by the National Space Development Agency of Japan (NASDA), and RADARSAT flown by the Canadian Space Agency (CSA). ASF receives and archives SAR data for the US user community from ground stations at ASF and McMurdo base in Antarctica. ASF provides new acquisitions and archival data for many important geophysical disciplines, including sea ice, polar oceanography, volcanology, glaciology, wetlands ecosystems, forestry, geology, and oceanography. Examples of large scale campaigns or intense mapping projects are the Antarctic Mapping Mission, Global Rain Forest Mapping Project, and the Global Boreal Forest Mapping Project. This special session highlights these key disciplines and mapping campaigns. The paper will provide an overview of the SAR sensors, product characteristics, data availability and ordering procedures. Also, the paper will discuss software tools for users and planning for future sensors and activities.

I. Introduction.

The Alaska SAR Facility (ASF) is the NASA Distributed Active Archive Center (DAAC) that provides SAR (synthetic aperture radar) data and data products to polar and earth systems science communities and to operational communities. SAR is an active microwave sensor useful in all weather or lighting conditions, providing a fine resolution (10-100m) two-dimensional map of natural surfaces. Information is provided in the form of radar backscatter, where transmitted signals are scattered from the varying roughness components of the surface. Such a sensor is well suited for use in many disciplines, perhaps particularly in those regions dominated by cloud cover and/or the lack of sunlight including the polar and equatorial regions as well as over the ocean.

ASF was established by NASA at the University of Alaska Fairbanks as a joint venture with the Jet Propulsion Laboratory and has been operational since 1991. The ASF emphasis is on acquiring, calibrating, processing, distributing, and archiving SAR data from international satellites for the user community. ASF also supports the user community in many ways, especially by helping users order and acquire data, by developing tools such as those for interferometry analysis and large scale mosaicking, and by providing education outreach for SAR.

ASF currently supports the ERS-1 and ERS-2 flown by the European Space Agency (ESA), JERS-1 flown by the National Space Development Agency of Japan (NASDA), and RADARSAT flown by the Canadian Space Agency (CSA). ASF functions under agreements between NASA and the international space agencies owning the satellites to make SAR data available to approved users at little or no cost. More information on these data sets is available through the ASF Web Page (http://www.asf.alaska.edu). As shown on Table 1, each SAR sensor has different operating parameters: frequency, polarization, pointing angle, and swath width. The ERS and RADARSAT sensors employ C-band at a wavelength of about 5 cm and a frequency of about 5.3 GHz while JERS-1 employs L-band at a longer wavelength (23 cm) and lower frequency (1.2 GHz). Surface scattering from ocean, land, and ice principally arises from roughness components that have similar wavelengths to the specific radar wavelength (called Bragg scattering). Also, the radar can penetrate into certain radar-transparent surfaces (including ice, sand, and within vegetation canopy) resulting in so-called volume scattering. Combining surface and volume scattering results in fine discrimination of varying surface features and conditions. In general, C-band is more preferred for ice and ocean studies, while L-band is preferred for land and forestry applications. Also, the VV polarization (ERS 1 and 2) results in higher returns than HH (JERS-1 and RADARSAT), but each polarization may also have varying contrasts between natural surface types. ERS and JERS-1 operate at fixed incidence angles and swath widths while RADARSAT has the capability for varying both incidence angle and swath width.

ASF receives and archives SAR data for the US user community from US owned and operated ground stations at ASF and McMurdo base in Antarctica. Direct downlinks from ERS-2, JERS-1 and RADARSAT can be received at these two stations. In addition, direct downlinks from RADARSAT can be received at any of a number of foreign ground stations or data can be recorded on an on-board tape recorder (the JERS-1 on-board tape recorder is currently malfunctioning) for playback and downlink at ASF. RADARSAT thus has global access for data acquisitions. Acquisitions of both ERS SAR

sensors can only be obtained through direct downlink to ground reception stations. Figures 1 and 2 show the ASF and McMurdo station mask reception zones for the various satellites.

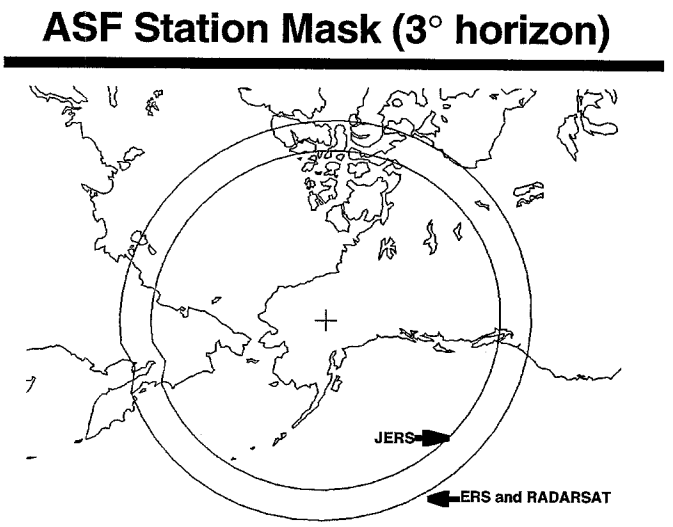

Figure 1. The nominal limit of the reception zones for ASF are shown for the four international SAR satellites.

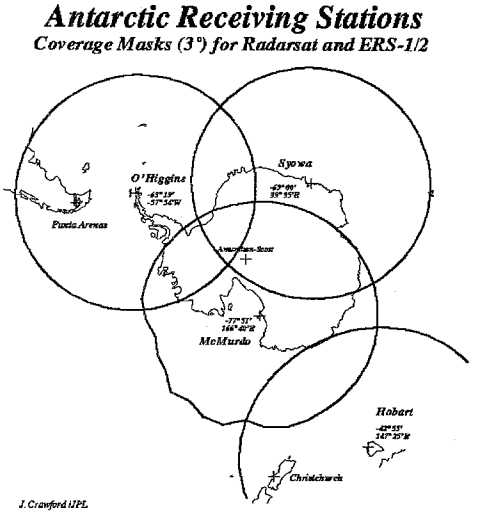

Figure 2. The nominal reception limit of NASA's McMurdo station is shown for three international SAR satellites. The other 3 ground stations are operated by Germany (O'Higgins), Japan (Syowa), and Australia (Hobart).

All data archived at ASF are available for scientific investigations (both U.S. and international) at the cost of media reproduction upon approval by NASA of a two-page project summary submitted to ASF (details are available on the ASF home page). Data from these satellites that are not archived at ASF can be obtained at commercial pricing directly from the specific space agencies or their commercial agents to those who are not NASA-approved. Of course, scientific investigators who are approved by NASA (through ASF) or by the specific flight agency may also receive data at significantly reduced cost.

The ASF is designed to be a full-service DAAC. In addition to data reception and archive, it processes data into images, called Level 1 products, for distribution to the user community. ASF presently archives signal data, but is planning to move to a Level 0 file-formatted archive. User Services is the primary point for contact providing a human interface with ASF. It is designed to aid users in obtaining data and services. User Services is designed to provide help, obtain information and offer referrals for a wide variety of science, technical, operational, etc., questions. User Services can be reached via Internet at the primary address *asf@eos.nasa.gov,* at the alternate address *uso@eosims.asf.alaska.edu,* or by telephone at *907-474-6166.*

ASF has demonstrated impressive capacity for producing Level 1 products. It has two distinct Level 1 formation channels offering a variety of user products. ASF has demonstrated that it is capable of creating and distributing more than 3000 Level 1 products per month. The standard mix of products would include JERS-1, ERS-2, and RADARSAT standard and scanSAR beams for a range of operational and scientific users. A typical monthly breakdown would show that 80% of the capacity goes to large programs and individual scientists, operational users (e.g., National Ice Center) receive 10% of capacity, and internal calibration and validation activities receive the remaining 10%.. Of the first category, four large mapping missions get 56% with the rest to going to 152 individual projects.

The ASF SAR data are available in the following formats: full resolution (around 25 m), low resolution (reduced from full resolution, around 100 m), and complex (suitable for deriving land topography using radar interferometry). The data can be supplied on tape media or by file transfer. In addition, derived or geophysical products will be available in the near future from RADARSAT through the RADARSAT Geophysical Processing System (RGPS). These higher level products are derived primarily for sea ice studies (ice motion, ice type, ice age).

II. Current Projects

Currently, ASF provides new acquisitions and archival data for many important geophysical disciplines, including sea ice, polar oceanography, volcanology, glaciology, wetlands ecosystems, forestry, geology, and oceanography. The two US ground stations clearly provide a polar-emphasis to many of these disciplines but ASF supports global investigations of both large and small dimensions. The four large mapping missions, or large scale study campaigns, presently in effect are the RADARSAT Antarctic Mapping Program (RAMP), the Global Rain Forest Mapping Project which includes the Amazon, the Global Boreal Forest Mapping Project, and the RADARSAT Geophysical Processor and Arctic Snapshot

Program. Examples of smaller scale studies are the over 90 individual principle investigator projects and the over 60 ADRO (Advanced Development Research Opportunity) projects presently in effect. This session highlights these key disciplines and mapping campaigns.

RAMP

The RAMP (RADARSAT Antarctic Mapping Project) includes two complete mappings of the Antarctic using the left-looking mode of the Canadian RADARSAT satellite. ASF plays a major role in the Antarctic Mapping Mission (AMM), the data acquisition portion of RAMP. AMM I, the first mapping, was accomplished in September and October of 1997 with the second mapping scheduled two or three years hence. The mission has important significance for the scientific community; almost 70% of the Earth's fresh water is contained in the Antarctic region, and changes in that enormous reservoir directly influence world sea levels. The nearly simultaneous data record of the ice sheet and exposed portions of the continent will help to better understand why changes in the ice sheet occur. This may provide more insight into the effects of human activity and global warming on the rapid retreat of large portions of the ice shelves in the Antarctic Peninsula. Using RADARSAT images, scientists will be able to examine for the first time in history similar processes occurring across the entire continent (Fig. 3).

GRFM

The GRFM (Global Rain Forest Mapping) program goals are the contiguous coverage of the Earth's tropical rainforests, continental scale extension of forested versus non-forested area, assess extent of the annual flooding of major river systems, assess deforestation and human encroachment, etc. This program is a joint project between National Space Development Agency (NASDA, Japan), Ministry of International Trade and Industry (MITI, Japan), Earth Resources Satellite Data Analysis Center (ERSDAC, Japan), ASF, NASA Jet Propulsion Laboratory (JPL), the Joint Research Centre (JRC) (Italy), and others. The GRFM uses the Japanese JERS-1 Synthetic Aperture Radar (SAR) to map the Amazon rain forests, making use of the preferred L-band frequency for forestry which provides improved discrimination of the vegetation types. ASF served as receiving station for the data and is responsible for producing and distributing about 5,000 Level 1 products for two distinct mappings of the Amazon coverage of Central and South America.

GBFM

The GBFM (Global Boreal Forest Mapping) program goals are to map the world's boreal regions, monitor circumboreal baseline and changes, model regional circumboreal changes, and to provide information for use in economic and social planning. This program is a joint project between NASDA, Earth Observation Research Center (EORC, Japan), ASF, JPL, JRC, SSC of Sweden, and others. The GBFM uses the Japanese JERS-1 Synthetic Aperture Radar (SAR) to map the world's boreal regions, again making use of the preferred L-band frequency. ASF served as receiving station for the data and is responsible for producing and distributing about 12,000 Level 1 products for the boreal forest coverage of North America.

RGPS

The RGPS is designed to produce geophysical products, Level 2/3 products, from RADARSAT data of the Arctic Ocean. It requires periodic collection of a large volume of data for basin-scale production of geophysical products ranging from ice motion to ice thickness, ice age, backscatter, etc. In fact, RGPS represents approximately a third of the total U.S. allocation of SAR on-time of the RADARSAT sensor and a third of the production capacity of one SAR formation channel at ASF. The coverage requirements of the RGPS, the polar science community and NOAA National Ice Center (NIC) are blended together into the so-called Arctic Snapshot.

ADRO

The ADRO (Application Development and Research Opportunity) program is a research opportunity jointly sponsored by NASA, CSA and RSI (RADARSAT International). Program goals include understanding the geophysical and biological processes in the Earth system with emphasis on climate processes and Earth habitability. 61 projects have been funded for both polar and non-polar investigations of solid Earth/archeology, ecology, hydrology, sea ice, glaciers/ice streams, oceanography and operational applications. Some results are presented in this session.

III. Ordering Imagery from the Alaska SAR Facility

The EOSDIS has developed a multi-DAAC search and order system called the IMS (Information Management System). This is a prototype system and is still in work, but it does provide access to all the DAACs. With this system, researchers have the capability to search for data based on a number of criteria that include time, space, geophysical parameter, sensor and instrument. There is a feature-rich X-terminal version, accessible by telnet (either by 'telnet eosims.asf.nasa.gov 12345') and a Web version which is developing rapidly and which is more user friendly (http://harp.asf.nasa.gov/v0ims). Again, to obtain SAR imagery from ASF, users must first obtain individual approval as discussed above, so an account number can be assigned.

IV. Present and Future User Capabilities

ASF acquires, modifies, and maintains software which enables the user community to perform basic manipulation of ASF SAR data and derived products. The purpose of this activity is to ease the burden on the ASF user community from dealing with common engineering issues related to post-processing

tasks common to SAR data. This allows the user to concentrate on scientific research related to the use of SAR data without the need to create these tools. Examples of existing software tools include programs allowing the user to: stage data from tape to disk; examine CEOS metadata records; perform radiometric calibration to determine sigma zero; geocode data, perform terrain correction; and mosaic SAR scenes.

Tools are available for both Sun Microsystem and Silicon Graphics workstation architectures. Information about the support activity is maintained on the ASF web site (http:www.asf.alaska.edu) along with direct access to full documentation and automatic FTP transfer of individual tools or larger packages. Many of the tools have been updated to work with RADARSAT data products. New tools are continuously under development. Two such examples are the RADARSAT Fine Beam and INSAR processing capabilities presently in development. In addition, new tools are planned for extracting precision timing and state vector information, for processing RADARSAT extended high beam, etc. In the near future, we hope to add support for additional architectures including personal computer (PC) based tools.

V. Future Mission Support

ASF works with NASA and the science user community to help plan for future SAR satellites and multisensor programs. Specifically, ASF helps to plan technical and scientific mission support for next generation programs. In addition, ASF works with NASA to facilitate access to data from other flight agencies, such as the Canadian Space Agency (CSA), the European Space Agency (ESA) and the National Space and Development Agency (NASDA) of Japan.

ASF continues to work with ESA for ERS-1 and 2, with the CSA for RADARSAT, and with NASDA on JERS-1 and ADEOS. Future missions important to the general SAR user community include RADARSAT II, ENVISAT, TOPSAR, LightSAR, ALOS, and ADEOS II. In particular, ASF continues to:

- Investigate the progress of RADARSAT II with the CSA and work with NASA to procure the data for the research community;
- Evaluate the feasibility of accessing ENVISAT data from ESA;
- Support planning and development of TOPSAR and LightSAR;
- Investigate future plans for SAR sensors and ADEOS II data with NASDA;
- Evaluate potential contributions by ASF to the NASAs Office of Earth Science and EOS programs.

Acknowledgements. This work was carried out at the University of Alaska Fairbanks, and by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

TABLE 1
ASF SAR MISSION DESCRIPTIONS FROM THE NASA ESE INTERNATIONAL PARTNERS

INSTRUMENT	AMI	JERS-1	RADARSAT
SPACECRAFT	ERS-1,2		
SAR			
FREQUENCY	C-band	L-band	C-band
POLARIZATION	VV	HH	HH
SWATH	100 km	75 km	50-500 km
RESOLUTION	25 m	18 m	10-100 m
INCIDENCE ANG	23°	35°	20° - 50°
ORIENTATION	right	right	right*
DATA STORAGE	none	20 min**	20 minutes
ORBIT			
INCLINATION	97.5°	98.5°	98.5°
ALTITUDE	785 km	568 km	790 km
REPEAT	3, 35, 168 days	44 days	24 days
MISSION			
LAUNCH	ERS-1:July,'91 ERS-2:Ap,'95	Feb.,'92	Nov., '95
LIFETIME	3-5 years	8 years	5 years
STATUS	operational#	operational	operational
AGENCY	ESA	NASDA	CSA

*Except during the Antarctica Mapping Mission when it looked left
**Recorder currently not operational
#ERS-1 has been in orbital storage since June 1996 but could be activated for dedicated time periods.

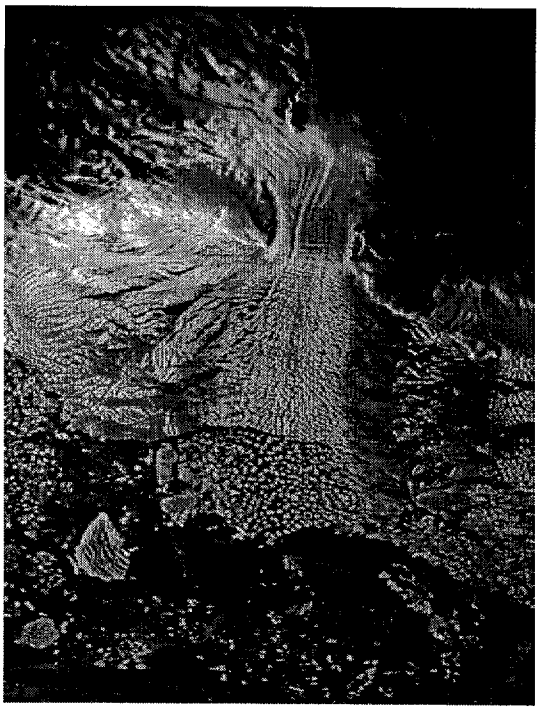

Figure 3. Radarsat image of Land Glacier, Antartica, obtained during AMM I.